

Hibernation Sites and Temperature Tolerance of Two Species of *Vespula* and One Species of *Polistes* (Hymenoptera: Vespidae)

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Abstract: The range of temperatures encountered at hibernation sites of *Vespula maculata* (Linnaeus), *Vespula arenaria* (Fabricius), and *Polistes fuscatus* (Fabricius) during the winter and spring of 1971-72 are presented. The tolerance of each species to temperatures below freezing was determined. All individuals of both *Vespula* species tested were killed by -10°C , while all *Polistes fuscatus* tested were killed at -20°C . These lethal temperatures were lower than the minimum temperatures observed at the hibernation sites.

INTRODUCTION

In temperate regions overwintering queens of the genus *Vespula* frequently hibernate in rotting logs and similar situations (Evans, 1963; Rau, 1929), while wasps of the genus *Polistes* hibernate in walls of buildings, under shingles, and in cracks in boards (Eberhard, 1969). Rau (1934) found that the queens of *Vespula maculata* (Linnaeus) constructed individual cells within the wood, and speculated that temperatures at the hibernation site were lower than in the surrounding area. The present paper reports the range of temperatures encountered during the winter and spring at a hibernation site of *Vespula maculata* (Linnaeus) and *Vespula arenaria* (Fabricius), and the tolerance of these two species and of *Polistes fuscatus* (Fabricius) to temperatures below freezing.

During October and November of 1971, a total of 86 *Vespula maculata* queens, 64 *Vespula arenaria* queens, and 88 *Polistes fuscatus* queens were found hibernating on the grounds of the Erindale campus of the University of Toronto in Ontario, Canada. The *Vespula* queens were located on the floor of the forest near the base of a stump in litter composed almost entirely of chips of decaying wood. The hibernating queens were found at depths ranging from one to twelve centimeters and were often found in individual cells of the type described by Rau (1934). The *Polistes* queens were collected around buildings, and most were taken near the window frame of an old shed.

Because both *Vespula* species construct distinctive aerial nests (Miller, 1961), it was possible to count the number of nests of each species in the forest. After an extensive search, only six nests of *Vespula arenaria* were found.

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However, ten nests of *Vespula maculata* and four additional nests of *Vespula arenaria* were found on the college grounds adjacent to the forest. Apparently, the queens of *Vespula maculata* found at the hibernation sites had come from areas outside the forest.

MATERIALS AND METHODS

Readings of the temperature of the litter at two *Vespula* hibernation sites were taken from early November to May. These sites were only two meters apart and had accounted for about one third of the total number of queens captured; they were assumed to be preferred locations. One of the sites had litter 12 cm. deep and temperature probes were placed at the surface, at 6 cm. and at 12 cm. At the second site, the litter was only 6 cm. deep, and the probes were placed at the surface and at 6 cm.

Reading of litter temperatures and the air temperature at a height of 1 m. were taken several times a month. Care was taken to obtain readings during periods of unusually cold weather. Occasionally, throughout the winter, temperatures were taken at the *Polistes fuscatus* hibernation sites in the shed.

An attempt was made to determine if a detectable daily litter temperature cycle occurred during the months of complete snow cover. During one 24-hour period in late winter, when the snow depth was 15 cm., readings were taken every 6 hours. The air temperature varied from $-5^{\circ}\text{C}.$ to $7.5^{\circ}\text{C}.$ while litter temperatures remained constant at $0.0^{\circ}\text{C}.$ Consequently, since daily temperature fluctuations were apparently absent in the litter during the months of complete snow cover, no attempt was made to take temperature at a standard time. A reading in the morning is assumed to give the same litter temperature as an afternoon reading.

When snow cover was absent, large fluctuations in temperature ($21^{\circ}\text{C}.$) were observed in the litter during the course of a day. During these periods, temperature readings were taken mainly during the afternoon, and no attempt was made to determine the minimum and the maximum for any one day. Consequently, litter temperatures taken in the absence of snow cover are used only as a conservative indicator of the earliest and latest date for the occurrence of freezing temperatures.

The temperature tolerance of the queens of *Vespula maculata*, *Vespula arenaria*, and *Polistes fuscatus* was determined by exposing groups of wasps to specific temperatures for 48 hours and then noting how many had died. These temperatures were $0.0^{\circ}\text{C}.$, $-5.0^{\circ}\text{C}.$, $-15^{\circ}\text{C}.$ and $-20^{\circ}\text{C}.$ $\pm .5^{\circ}\text{C}.$ Prior to the temperature tolerance experiments, the wasps had been maintained at $+5^{\circ}\text{C}.$ for two to three months during which time death rates of 3% for *Vespula maculata*, 11% for *Vespula arenaria*, and 8% for *Polistes fuscatus* were observed. The individuals of each species of wasps were divided into four groups of ten, and each group was exposed to one of the test temperatures for 48 hours.

TABLE 1. Maximum and minimum temperatures observed at a hibernation site of both *Vespula arenaria* and *Vespula maculata* during the period of complete snow cover, (December 31, to March 31) based on readings taken several times per month (total = 14).

Location of Probe	Maximum	Minimum	Range
Air	+7.5°C.	-13.5°C.	21.0°C.
Surface	1.0	- 6.5	7.5
6 cm.	1.0	- 2.5	3.5
12 cm.	1.5	- 1.5	3.0

After the test, the groups were returned to +5°C. and examined for movement. *Polistes fuscatus* was the only species exposed to -20°C.

RESULTS

Freezing temperatures were first observed at the surface of the litter on December 18, at 6 cm. on January 15, and at 12 cm. on January 26. Freezing temperatures were last recorded at the surface of the litter on March 31, and at 6 cm. and 12 cm. on April 11. The litter was an effective insulator. On December 18, when there was no snow cover and the air temperature was -12.5°C., the temperatures of the litter were -5.0°C. at the surface, 0.0°C. at 6 cm., and 2.0°C. at 12 cm. The effect of snow cover was to damp out daily temperature fluctuations.

The litter was completely covered with snow from about December 31 to March 31. Table I shows the maximum and minimum temperatures observed during this period. The temperature of the litter showed much less variation than the air temperature, and the observed temperature range decreased with depth. The lowest air temperature observed occurred on the night of January 26, 1972, and was -13.5°C. The corresponding temperatures for the litter were -6.5°C. at the surface, -2.5°C. at 6 cm., and 0.0°C. at 12 cm. At this date the snow cover was about 10 cm. The temperature of the hibernation sites in the shed was found to be similar to the air temperature.

TABLE 2. Survival of queens of *Vespula arenaria*, *Vespula maculata*, and *Polistes fuscatus* after exposure for 48 hours to various temperatures, based on 10 individuals of each species for each temperature.

Temperature	Percent survival at each temperature		
	<i>Vespula arenaria</i>	<i>Vespula maculata</i>	<i>Polistes fuscatus</i>
0.0°C.	100%	100%	100%
-5.0	80	100	100
-10.0	0	0	100
-15.0	0	0	90
-20.0	-	-	0

The results of the temperature tolerance experiments are shown in Table II. Between $-5^{\circ}\text{C}.$ and $-10^{\circ}\text{C}.$, the survival of both species of *Vespula* went from 80% in *Vespula arenaria* and 100% in *Vespula maculata* to 0.0% for both species. In comparison, *Polistes fuscatus* queens had 100% survival at $-10.0^{\circ}\text{C}.$ and 90% at $-15.0^{\circ}\text{C}.$ None of the *Polistes fuscatus* survived $-20.0^{\circ}\text{C}.$

DISCUSSION

The difference between a temperature that could be tolerated by most individuals and a temperature that killed all the individuals was only $5^{\circ}\text{C}.$ for the three species. These tolerance ranges corresponded closely to the minimum temperatures observed at the hibernation sites. In the litter, the lowest temperature, $-6.5^{\circ}\text{C}.$, was observed at the surface, and temperatures increased with depth. At 12 cm., the temperature was never below $-1.5^{\circ}\text{C}.$ Since temperatures as low as $-10^{\circ}\text{C}.$ did not occur in the litter, any *Vespula maculata* and *Vespula arenaria* present should have had a low winter mortality.

In contrast to the relatively warm hibernation sites required by the *Vespula* species, *Polistes fuscatus* can withstand temperatures as low as $-15.0^{\circ}\text{C}.$ and can survive in far less sheltered above ground situations. However, since air temperatures of $-20^{\circ}\text{C}.$ usually occur in Southern Ontario each winter, some protection from the weather is required. During cold winters, structures such as the shed would be unsuitable as a hibernation site, and winter survival may be restricted to those *Polistes fuscatus* that hibernate in buildings.

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